Dose evaluation using existing plan parameters of auto-contouring in head-and-neck radiotherapy

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Track: Physics

Topic: Autosegmentation

Keywords: Dosimetric Impact, Scripted Plans, Head-and-neck

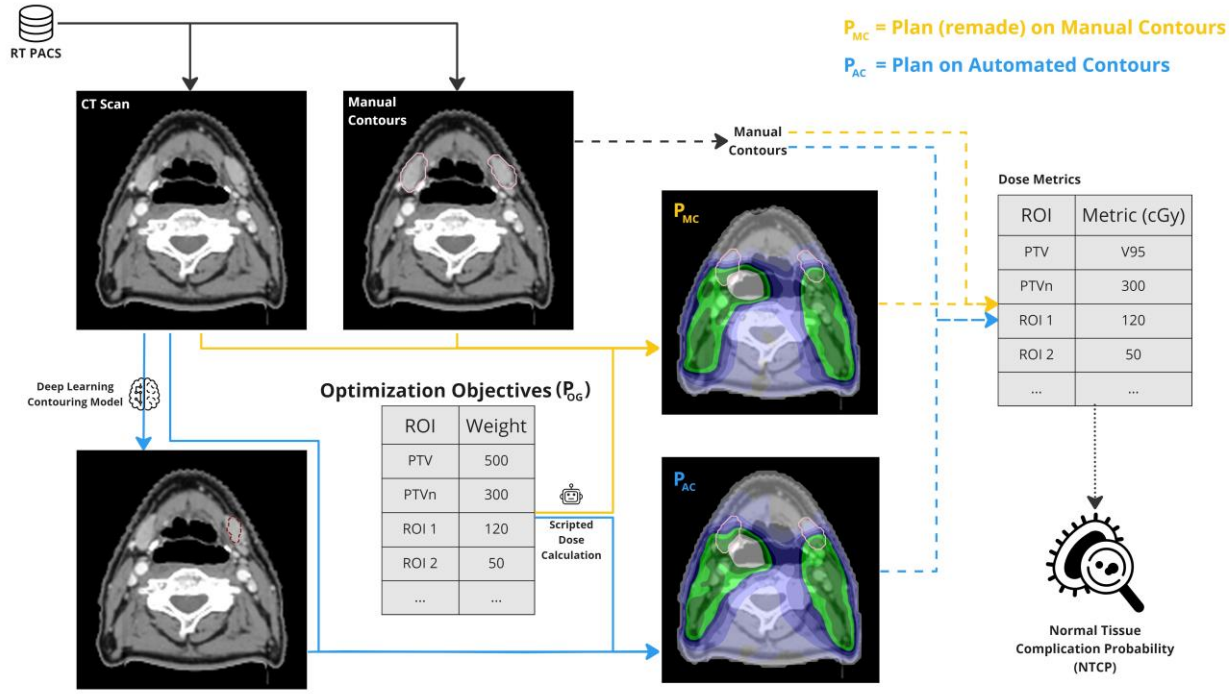
Word Count (on ESTRO portal): 744/750

Purpose/Objective

Previous work on auto-contour dose evaluation has used both manual[1] and automated[2,3] techniques, however with small (~20) test patient cohorts. This is due to extensive manual effort required for additional contour refinement and treatment planning on the auto-contours. Moreover, automated planning techniques, if not already clinically implemented, are difficult to adopt. Our primary goal is to investigate the dosimetric effect of auto-contouring for photon radiotherapy using a large-scale cohort of patients. A secondary goal is to develop and evaluate a workflow that is both automated and uses existing plan parameters, hence enabling evaluation for a large patient cohort.

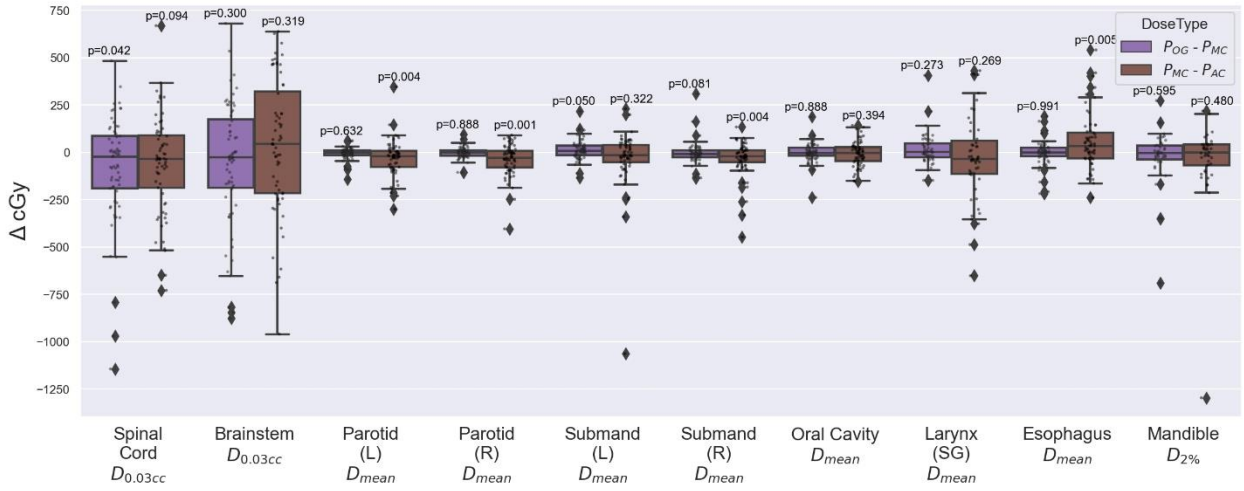
Material/Methods*

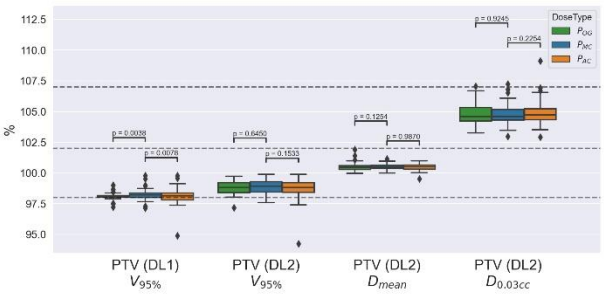
For large-scale plan creation, we developed a 5-step automated program that emulates our clinics treatment planning protocol and leverages plan optimization parameters from the original clinical plan (P_{OG}) of a patient. In the first step we maximize dose to tumors followed by three steps involving dose minimization for organs-at-risk. In the fifth step we use custom contours to sculpt the dose and deal with cold and hot spots. For a fair comparison, the same program recreates the clinical plan with manual organ contours (P_{MC}) as well as another plan where eight organ contours are automated (PAC). Note that manual contours used for automated plan creation and evaluation of all plans are taken from the clinic without further refinements, since these were already deemed acceptable for clinical dose delivery. Auto-contours were generated for the Spinal Cord, Brainstem, Parotid (L/R), Submandibular (L/R), Oral-Cavity, Esophagus, Mandible and Larynx (Supraglottic). The Python 3.6 scripting interface of Raystation-10B (Raysearch Labs, Sweden) and its autocontouring model - "RSL Head and Neck CT" (v1.1.3) was used to generate our automated plans and automated contours respectively. We use volumetric modulated arc therapy (VMAT) to generate a 6 MV dual arc photon plan on a 0.2 cm isotropic dose grid. Our approach is tested on 70 head-and-neck patients who were diagnosed with either oropharyngeal (71%) or hypopharyngeal (29%) cancer. We compare plans by evaluating dose (i.e. Δ cGy) on manual contours of organs and targets as well as differences in Normal Tissue Complication Probability (NTCP).

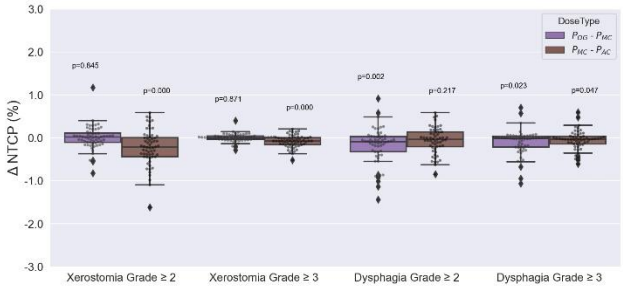


Results*

We evaluate our secondary goal by investigating the fidelity of our automated planning approach (i.e. $P_{OG} - P_{MC}$). An absolute average dosimetric impact of 2.6% is observed on organs which were automated. The Parotids, Submandibulars, Oral Cavity, Larynx, Esophagus and Mandible have small values for ΔD_{mean} (~0.4Gy), while the Spinal Cord and Brainstem have comparatively wider box-plots. For PMC, our automated workflow is able to recreate 87% of patients strictly meeting target coverage criteria. Automated planning takes on average 1.5 hours of compute time for each patient compared to 4 hours for manual planning. For our primary goal (i.e. P_{MC} - P_{AC}), we observe the absolute average dosimetric impact for organs which were automated to also be small (~4.5%). Most DICE values are above 0.8, but the Brainstem and Larynx have reduced DICE due to incomplete contours in the clinic or a difference in the contouring protocol. Moreover, the $\Delta D_{0.03\text{cc}}$ metric of the Brainstem and Spinal Cord shows larger values compared to the ΔD_{mean} metric due to its inherent sensitivity. Finally, ΔNTCP results show that, on average, there exist minuscule differences (≤ 1%) for P_{OG} - P_{MC} as well as P_{MC} - P_{AC}.







Conclusion*

In a case study of head-and-neck cancers, our secondary goal of plan automation is successful in recreating the original clinical plans in a majority (87%) of cases, with the remaining cases being only slightly inferior in terms of target coverage. Note that in a dose-evaluation scenario, plans which are almost-perfect can already provide us with an estimation of the effect of a contour on the dose. Thus, such plans are sufficient to guide a clinic on whether a specific contour can be used in clinical practice. Also, other clinics can replicate our workflow by simply interfacing with their treatment planning system (TPS) via a step-by-step program of their planning technique. This approach requires minimal additional expertise since many TPS solutions already provide documentation on using the Python programming language for their software. For our primary goal, we observe a low dosimetric and toxicity impact of using auto-contours, in spite of geometric differences between manual and auto-contours. While low DICE values in some organs (e.g. Larynx and Esophagus) lead to a mild increase in dose, others (e.g. Brainstem and Spinal Cord) have almost no correlation with DICE. This insight can guide clinicians on which contours can be safely automated in clinical workflows.

To conclude, with a faster and easier dose evaluation approach and proof of minimal impact of auto-contours in the head-and-neck case, we hope to facilitate adoption of autocontouring in clinics.

References

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